OCCURANCES OF TERM "SURFACE TENSION" IN DIV. APPL.

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TITLE: Underfile process

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A method and apparatus for underfilling a gap between a semiconductor die or device and a substrate, where the semiconductor die or device is electrically connected to the substrate so that an active surface of the semiconductor die is facing a top surface of the substrate with the gap therebetween. A silane layer is applied to the active surface of the semiconductor die, the upper surface of the substrate, and/or both to increase the surface **tension** thereon. The increased surface **tension** thereby allows the underfill material to fill the gap via capillary action in a lesser flow time more effectively, and therefore, is more efficient than conventional underfilling methods.

[0013] The present invention relates to a method and apparatus for underfilling the gap between a bumped or raised semiconductor device and a substrate. The present invention is directed to a method and apparatus for filling the gap between a semiconductor die and a substrate using underfill material where the semiconductor die is electrically and mechanically connected to the substrate. The method and apparatus includes the use of a wetting agent on at least a portion of the surface of the semiconductor die forming a portion of the gap between the semiconductor die and a substrate to which it is mounted and/or a wetting agent on at least a portion of the substrate forming a portion of the gap to increase the surface **tension** between the underfill material and the

surface of the semiconductor die and/or the substrate. One embodiment of the present invention includes a layer of silane as a wetting agent on at least a portion of the active surface of the semiconductor die and/or a layer of silane on at least a portion of the upper surface of the substrate to which the semiconductor die is mounted, each layer of silane increasing the surface **tension** thereon, the increased surface **tension** allowing the underfill material to fill the gap between the semiconductor die and the substrate via capillary action forces in a lesser length of time. Various wetting agents may be used according to the present invention, such as glycidoxypropyltinethoxysilane and ethyltrimethoxysilane.

[0038] To promote filling of the gap 26 between the substrate 10 and semiconductor die 12, the viscosity of the underfill material 28 is controlled taking into account the flow characteristics of the underfill material 28, the material characteristics of the substrate 10, the material characteristics of the semiconductor die 12, and the size of the gap 26. By providing the silane layer 2 to the substrate 10 and the semiconductor die 12, the material characteristics of the surfaces thereof are changed so that the surface **tension** is increased. Accordingly, the underfilling of the gap 26 takes less time, allowing for a more efficient underfilling process.

[0044] .sigma. is the surface-**tension** coefficient of the underfill material; and

[0046] As shown in the above equation, manipulation of the contact angle .theta. can either decrease or increase the flow time t for filling the gap 2. As illustrated in drawing FIG. 2, the contact angle .theta. is the angle by

which the underfill material 28 makes contact with the surface of the substrate 10 and the semiconductor die 12 via the constant capillary force driving the flow. The contact angle .theta. may be reduced by increasing the surface **tension** of the substrate 10 and semiconductor die 12, which results in a drop of flowing time. For example, according to the equation above, reducing the contact angle .theta. from 30.degree. to 10.degree. will reduce the flow time t for filling the gap 26 between the substrate and chip by 12%.

[0047] Thus, it can be appreciated that by pretreating the surfaces of the substrate 10, the semiconductor die 12, and/or both, with a silane layer 2, as previously set forth, a wetting effect to the surface thereof results in an increased surface **tension**. In this manner, the contact angle .theta. is reduced, resulting in a decrease in flow time t and a more efficient and cost-effective method for underfilling the semiconductor device.

[0055] The dam 40 limits the expansion or gravitational flow of the underfill material 28 beyond the position of the dam 40. During the underfill procedure, the underfill material 28 coats and spreads out onto the surfaces of the semiconductor die 12 and substrate 10. The dam 40 prevents the spread of underfill material 28 beyond the side end 30' of the semiconductor die 12 by means of surface **tension**.

5. The semiconductor device according to claim 1, wherein said wetting agent layer reduces surface **tension** of said active surface.

30. The semiconductor device according to claim 26, wherein said wetting agent layer reduces surface **tension** of said active surface.